

**CARBONATES AND FELDSPATHIC GLASS IN ALH84001: ADDITIONAL COMPLICATIONS.** G. A. McKay<sup>1,2</sup>, T. Mikouchi<sup>2</sup>, and G. E. Lofgren<sup>1</sup>, <sup>1</sup>NASA Johnson Space Center, SN4, Houston, TX 77058, USA, <sup>2</sup>Mineralogical Institute, Graduate School of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113, JAPAN, email: gmckay@ems.jsc.nasa.gov; gmckay@min.s.u-tokyo.ac.jp

**Introduction.** ALH84001 is the well-known martian meteorite in which evidence for possible relict biogenic activity has been reported [1], especially in the carbonates. The issue of biogenic activity is of great philosophical and scientific importance, and yet remains highly controversial. Understanding the origin and history of the carbonates in this sample is one key to resolving this controversy.

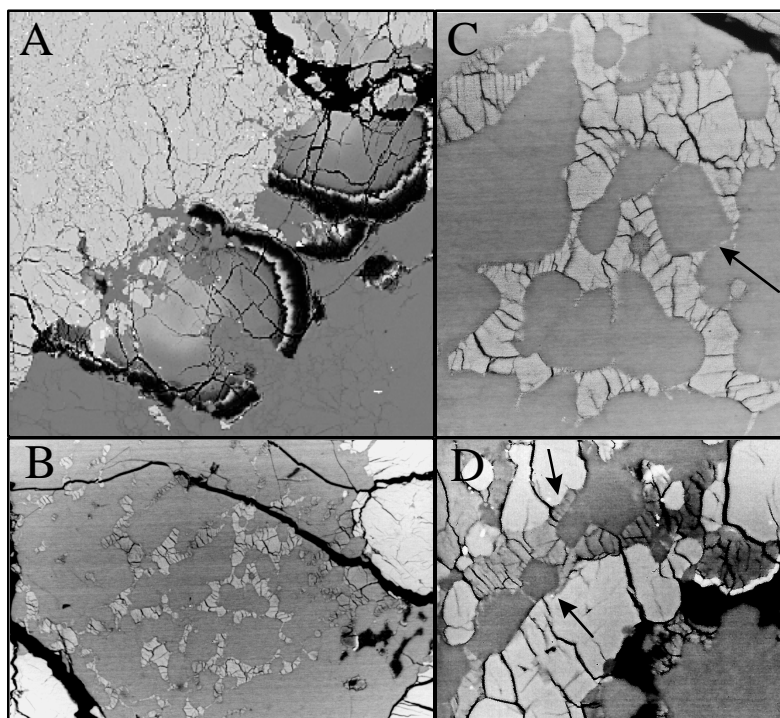
The general petrography of this sample was reported by [2,3], and many workers have studied the petrography and chemical composition of the carbonates [e.g., 4,5,6]. Carbonate has been reported as globules (or pancakes), vein fillings, interstitial material between pyroxene grains, and material filling fractures and pockets in pyroxene grains. Globules generally develop zoned rims on the side facing maskelynite-like feldspathic glass, but only rarely on the side facing pyroxene. Pyroxene and carbonates are always heavily fractured, while feldspathic glass is smooth. Fragments of globule rims and orthopyroxene are commonly entrained in the feldspathic glass. The above features can be seen in Fig. A. From chemical and textural evidence, we previously concluded that kinetic effects played a strong role in the formation of the carbonates [5]. Moreover, we suggested that the feldspathic glass was formed, or at least moved, after the carbonates were formed, causing their fracturing and disruption.

**Results.** In this abstract we report a new textural occurrence of carbonate that differs considerably from the occurrences we reported earlier, and places important constraints on the timing and mode of formation of the carbonates. This textural type is shown in Fig. B, and consists of a lacy framework of carbonate immersed in feldspathic glass. Optical inspection reveals that this lace is three dimensional, apparently extending completely through the entire thickness of the PTS.

At higher magnification (Fig. C), it appears that the carbonate is filling interstices between what were once euhedral or rounded grains of plagioclase,

now converted to glass by shock. The arrow in Fig. C points to one glassy area with a particularly well developed euhedral outline. As with other patches of feldspathic glass, this area is both optically and chemically heterogeneous.

Similar features are present in other areas. E.g., Fig. D shows a zoned (but not globular) carbonate grain that is impinged by euhedral embayments of feldspathic glass, both in the carbonate of intermediate composition (medium gray, arrows), and in the magnesite rim (dark gray, bottom center and right). We have not chemically analyzed this grain, but have no reason to expect its compositional trends will be any different from those of all the other carbonates we have analyzed to date, whether globular



BSE images of carbonates and feldspathic glass in ALH84001. **A.** Zoned globular carbonates. Note fragments of carbonate rims (dark color) and pyroxene (light color) in feldspathic glass (dark gray) Field width: 512µm. **B.** Patch of feldspathic glass (dark gray) containing lacy network of carbonates (light gray). Field width: 200 µm. **C.** Detailed view of region from Fig. B showing apparent relict euhedral plagioclase (dark gray, e.g., arrow) with interstitial light gray carbonate. Field width: 45 µm. **D.** Image showing relicts of euhedral plagioclase (dark gray, e.g., arrows) partially enclosed in carbonate. Carbonate is zoned like globules. By analogy with globules, compositions probably range from intermediate Fe,Mg,Ca (intermediate gray, heavily fractured) to magnesian siderite (bright band at center right) to magnesite (dark region below siderite). Field width: 60 µm.

or not [5].

**Discussion.** It seems clear from Figs. B-D that this textural form of carbonate grew in the interstices between small granular or euhedral feldspar grains. Also, this carbonate must have formed along with or after the feldspar. There are several possibilities for its origin: (1) Both minerals could have grown simultaneously in a metamorphic recrystallization or annealing event like the one in which the granular pyroxene formed [2,3]. (2) The plagioclase could have formed first, with void space somehow being present between the grains, which was subsequently filled by carbonate (unlikely, because the presence of void space between euhedral plagioclase is difficult to explain). (3) The carbonate could have replaced another interstitial mineral such as pyroxene (unlikely, because in other parts of the sample where carbonate is interstitial to granular pyroxene, it would have had to replace plagioclase). (4) Both minerals could have crystallized simultaneously during or after a shock event (shock melting of feldspar and carbonate was suggested by [6]), with the euhedral crystals being a high pressure mineral such as that reported by [7]. In this case, not all carbonate need necessarily have been melted by the shock event. Perhaps the globules are unmelted. More work will be required to distinguish between these (or other) possibilities for the origin of this texture.

**References:** [1] D. McKay *et al.* (1996) *Science* 273, 924-930. [2] D. Mittlefehldt (1994) *Meteoritics* 29, 214-221. [3] A. Treiman (1995) *Meteoritics* 30, 294-302. [4] R. Harvey and H. McSween (1996) *Nature* 382, 49-51. [5] G. McKay *et al.* (1997) *LPS XXVIII*, 921-922. [6] E. Scott *et al.* (1997), *LPS XXVIII*, 1271-1272. [7] A. El Goresy *et al.* (1997) *LPS XXVIII*, 329-330.